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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/624,537	07/23/2003	Katsuhiro Horikawa	M1071.1855/P1855	6662

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EXAMINER

MAYES, MELVIN C

ART UNIT

PAPER NUMBER

1734

DATE MAILED: 08/15/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

## Office Action Summary

**Application No.**

10/624,537

**Applicant(s)**

HORIKAWA ET AL.

**Examiner**

Melvin Curtis Mayes

**Art Unit**

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 02 June 2005.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1,4-17 and 21 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1,4-17 and 21 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
  - ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |  |   |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892)   | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)   | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152)             |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)<br>Paper No(s)/Mail Date <u>1/28/05</u> | 6) <input type="checkbox"/> Other: _____  |

## DETAILED ACTION

### *Specification*

(1)

The disclosure is objected to because of the following informalities: the amendment to the specification is partly illegible and should be resubmitted or amended.

Line 3 of the amendment to the specification is partially blocked and still illegible.

Appropriate correction is required.

### *Claim Rejections - 35 USC § 103*

(2)

The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

(3)

Claims 1, 4, 5, 7 and 14-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Randall et al. 2002/0079622 in view of Ponomarev et al. 2004/0012000 and Horikawa et al. 6,383,408.

Randall et al. disclose a method of making a cofired multilayered piezoelectric material such as an actuator or transformer comprising: forming a green body assembly of alternating layers of piezoelectric ceramic, such as PZT, and copper electrode layers; debinding; and co-sintering in an atmosphere of oxygen partial pressure of  $10^{-3}$  to  $10^{-10}$  atms [0025]-[0027]. Randall et al. do not disclose providing the piezoelectric PZT ceramic as one having a molar quantity of Pb reduced by 0.5-5 mol% from that of stoichiometric composition.

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Ponomarev et al. teach that to achieve high efficiency under dynamic operations such as in a multilayer piezoelectric ceramic transformer, low-loss hard piezoelectric ceramic materials are required [0002].

Horikawa et al. teach that a piezoelectric ceramic which has significantly low loss is a composition represented by the formula  $\text{Pb}_x\{(\text{Mn}_a\text{Nb}_b)_y\text{Ti}_z\text{Zr}_{(1-y-z)}\}\text{O}_3$ , where on a molar basis  $0.95 \leq x \leq 0.995$  (col. 2, lines 44-56). When the amount of Pb is decreased below stoichiometric content, no foreign phase exist in the sintered material, and hence a piezoelectric ceramic having an even lower loss can be obtained (col. 3, lines 14-18).

It would have been obvious to one of ordinary skill in the art to have modified the method of Randall et al. for making a cofired multilayered piezoelectric actuator or transformer by providing the piezoelectric ceramic as a PZT ceramic having the composition formula  $\text{Pb}_x\{(\text{Mn}_a\text{Nb}_b)_y\text{Ti}_z\text{Zr}_{(1-y-z)}\}\text{O}_3$ , where on a molar basis  $0.95 \leq x \leq 0.995$ , as taught by Horikawa et al., a piezoelectric ceramic which has significantly low loss because of Pb content decreased below stoichiometric content, as Ponomarev et al. teach that low loss piezoelectric ceramic material are required for piezoelectric ceramic transformers. Providing the PZT ceramic of the composition having Pb (A site component) of molar quantity reduced by 0.5-5 mol%, as claimed, would have been obvious to one of ordinary skill in the art, as Horikawa et al. teach that such a composition has low loss and as Ponomarev et al. teach that low loss is desired for multilayer piezoelectric ceramic transformers.

By co-sintering in an atmosphere of oxygen partial pressure of  $10^{-3}$  to  $10^{-10}$  atms as disclosed by Randall et al., the green body is obviously sintered in an atmosphere encompassed

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by or encompassing atmosphere of oxygen concentration of 5 vol% or less but more than 0 vol% as claimed.

By providing the piezoelectric ceramic of composition  $\text{Pb}_x\{(\text{Mn}_a\text{Nb}_b)_y\text{Ti}_z\text{Zr}_{(1-y-z)}\}\text{O}_3$ , the average valence of the B site component is greater than stoichiometric and greater than 4.000 but less than 4.100, as claimed in, and the B site component comprises Nb, as claimed in Claims 5, 7 and 15.

(4)

Claims 1, 4, 5, 7-11 and 14-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Horikawa 6,080,328 in view of Ponomarev et al. 2004/0012000, Horikawa et al. 6,383,408 and JP 11-163433.

Horikawa '328 discloses a method of making a piezoelectric ceramic element comprising: providing a piezoelectric ceramic of the formula  $\text{Pb}_a[(\text{Cr}_x\text{Nb}_{(1-x)})_y\text{Zr}_{(1-b-y)}\text{Ti}_b]\text{O}_3$ , wherein  $0.95 \leq a \leq 1.05$ ; producing green sheets; laminating green sheets with internal electrodes; and firing. Green sheets of thickness of 60-100  $\mu\text{m}$  can be coated with electrode paste of Ag/Pd of ratio 7/3 (col. 2, lines 39-67, col. 8, lines 5-35). Horikawa does not disclose limiting the Pb in the composition to molar quantity reduced by 0.5-5 mol% from that of stoichiometric composition or disclose firing (sintering) in an atmosphere of oxygen concentration of 5 vol% or less but more than 0 vol%.

Ponomarev et al. teach that to achieve high efficiency under dynamic operations such as in a multilayer piezoelectric ceramic transformer, low-loss hard piezoelectric ceramic materials are required [0002].

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Horikawa et al. teach that a piezoelectric ceramic which has significantly low loss is a composition represented by the formula  $Pb_x\{(Mn_aNb_b)_yTi_zZr_{(1-y-z)}\}O_3$ , where on a molar basis  $0.95 \leq x \leq 0.995$  (col. 2, lines 44-56). When the amount of Pb is decreased below stoichiometric content, no foreign phase exist in the sintered material, and hence a piezoelectric ceramic having an even lower loss can be obtained (col. 3, lines 14-18)

JP 11-163433 teaches that in making a piezoelectric transducer having Ag electrodes, diffusion of the Ag into the ceramic is reduced to 10-50 ppm by sintering in an oxygen density of 1-10% (computer translation [0029]).

It would have been obvious to one of ordinary skill in the art to have modified the method of Horikawa '328 for making a piezoelectric ceramic element by limiting the limiting the Pb in the composition to molar quantity reduced by 0.5-5 mol% ( $0.95 \leq a \leq 0.995$ ) from that of stoichiometric composition, as Horikawa et al. teach that such a composition has low loss because of Pb content decreased below stoichiometric content and as Ponomarev et al. teach that low loss is desired for multilayer piezoelectric ceramic elements. Limiting the Pb molar quantity as claimed would have been obvious to one of ordinary skill in the art to achieve lower loss, taught by Ponomarev et al. as desired for multilayer piezoelectric ceramic elements.

It would have been obvious to one of ordinary skill in the art to have further modified the method of Horikawa '328 by firing (sintering) the laminate in an oxygen atmosphere in the range of 1-10% oxygen density, as taught by JP '433, to reduce diffusion of the Ag into the piezoelectric ceramic. Sintering in an oxygen atmosphere of oxygen concentration in the range of up to 5 vol%, as claimed, would have been obvious to one of ordinary skill in the art as encompassed by the range of 1-10% taught by JP '433 to reduce diffusion.

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By providing the piezoelectric ceramic of composition  $\text{Pb}_a[(\text{Cr}_x\text{Nb}_{(1-x)})_y\text{Zr}_{(1-b-y)}\text{Ti}_b]\text{O}_3$ , the average valence of the B site component is greater than stoichiometric and greater than 4.000 but less than 4.100, as claimed and the B site component comprises Nb and Cr, as claimed in Claims 5, 7, 8 and 15.

(5)

Claims 6 and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over the references as applied to claims 1 or 4 above, and further in view of Feltz et al. 2002/0098333.

Feltz et al. teach that in piezoelectric ceramic, partial substitution of the quadrivalent cations Zr and Ti on the B-positions can be by a combination of two-valent metal cations such as Ni and quivalent metal cations such as Nb [0020].

It would have been obvious to one of ordinary skill in the art to have further provided Ni in addition to the Nb, as taught by Feltz et al., as metal cation that can be provided with Nb for partial substitution of Zr and Ti in piezoelectric ceramic. Providing Nb and Ni as part of the B-site component in partial substitution of Zr and Ti would have been obvious to one of ordinary skill in the art, as taught by Feltz et al.

(6)

Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over the references as applied to claim 11 above, and further in view of JP 2001-181035.

Horikawa '328 discloses firing at a temperature of 1100°C or less.

JP '035 teaches that in making a piezoelectric ceramic transducer, etc, if the burning temperature is made low, it is possible to use cheaper silver-palladium alloy as the internal electrode. To lower manufacturing cost, it is desirable to make the percentage of palladium be

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20% or less, which can be used with a burning temperature of 1000°C or less (computer translation [0004]).

It would have been obvious to one of ordinary skill in the art to have modified the method of the references as combined by coating the green sheets with Ag/Pd paste of at least 80% or 85% Ag, as taught by JP '035, to lower manufacturing costs by using cheaper Ag/Pd alloy. The use of an Ag/Pd paste of ratio of at least 80/20 or 85/15 would have been obvious to one of ordinary skill in the art to lower the manufacturing cost by using a cheaper Ag/Pd alloy.

By producing green sheets of thickness of 60-100 um, piezoelectric layers of thickness less than 64 um or 40 um after sintering are obviously provided.

### ***Response to Arguments***

(7)

Applicant's arguments filed June 2, 2005 have been fully considered but they are not persuasive.

Applicant argues that Horikawa '408 does not teach co-firing the piezoelectric ceramic with internal electrodes and argues that one would not sinter the ceramic in a reduced oxygen atmosphere such as that of Randall in that one would expect the product to be characterized by deteriorated piezoelectric constant. Applicant argues that the combination of Horikawa '328, Ponomarev, Horikawa '408 and JP '433 would not be made since it would result in deterioration of the piezoelectric d constant.



(8)

Randall et al. disclose a method of cofiring alternating layers of piezoelectric ceramic, such as PZT, and copper electrode layers without reducing the PZT by co-sintering in a reducing atmosphere of oxygen partial pressure of  $10^{-3}$  to  $10^{-10}$  atms. While Horikawa et al. does not disclose cofiring piezoelectric ceramic and electrodes, the suggestion of the reference to use a piezoelectric ceramic of composition  $\text{Pb}_x\{(\text{Mn}_a\text{Nb}_b)_y\text{Ti}_z\text{Zr}_{(1-y-z)}\}\text{O}_3$ , where on a molar basis  $0.95 \leq x \leq 0.995$  would have suggested to one of ordinary skill in the art to use such as composition in the method of Randall to achieve lower loss, which is also desired for multilayer piezoelectric ceramic as taught by Ponomarev. One would not expect the ceramic to have deteriorated piezoelectric constant when Randall clearly discloses that piezoelectric ceramic can be sintered in reducing atmospheres without being reduced.

The Examiner is not convinced that the combination of Horikawa '328, Ponomarev, Horikawa '408 and JP '433 would result in deterioration of the piezoelectric d constant because JP '433 teaches that sintering of piezoelectric ceramic with electrodes containing silver in an atmosphere of oxygen density of 1-10% to reduce diffusion of the silver in the ceramic still results in excellent piezoelectric property.

***Conclusion***

(9)

**THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.


(10)

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Melvin Curtis Mayes whose telephone number is 571-272-1234. The examiner can normally be reached on Mon-Fri 7:30 AM - 4:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chris Fiorilla can be reached on 571-272-1187. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

  
Melvin Curtis Mayes  
Primary Examiner  
Art Unit 1734

MCM  
August 12, 2005